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Results of Plumbtesmo Tailpipe Testing on Ten Vehicles Misfueled with 0.1 gm/gal Leaded Gasoline

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By

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September 1986

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16. ABSTRACT

This report presents the results of a misfueling study done by Automotive Testing Labs under EPA contract. This study was performed to evaluate the performance of Plumbtesmo brand lead sensitive paper in detecting the presence of lead on vehicle tailpipes after the vehicles were misfuled with 0.10 + 0.02 grams/gal leaded fuel (low lead fuel).

This report also addresses the concern whether the test paper can still be used in vehicle Inspection and Maintenance programs to detect the presence of lead deposits resulting from the use of the reduced lead content of gasoline.

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1.0 INTRODUCTION

This report is intended to present the results of a misfueling study done by Automotive Testing Labs under EPA contract. This study was performed to evaluate the performance of Plumbtesmo brand lead sensitive paper in detecting the presence of lead on vehicle tailpipes after the vehicles were misfueled with 0.10 $\pm$ 0.02 grams/gal leaded fuel (low lead fuel). Gasoline with this lead content is the new standard (Federal Register 50 FR 9386) and will eventually be the only leaded gasoline available in the marketplace. However, currently, because of lead "Banking" credits, the lead content of gasoline varies between 0.1 grams/gal and 1.0 grams/gal and currently averages about 0.3 grams/gal.

In several vehicle inspection/maintenance (I/M) programs lead-sensitive test paper is used to detect water soluble lead deposits in tailpipes. Concern has developed as to whether the test paper can still be used in I/M programs to detect the presence of lead deposits resulting from the use of the reduced lead content gasoline. This report will address this question.

2.0 CONCLUSIONS

Previous EPA studies (ref. 2) on continuous misfueling with leaded gasoline indicate that from one to six tanks of leaded gasoline at 1.0 gram/gal are required to initiate a positive Plumbtesmo reaction. The results of this present study indicate that Plumbtesmo can also detect the presence of lead in tailpipes following misfueling with 0.1 gram/gal gasoline. The number of continuous misfueling episodes is still from one tank to about six tanks of the reduced lead content fuel with most vehicles showing a positive reaction after only four tanks. The testing also showed that Plumbtesmo could be used to detect the results of misfueling on oxygen sensors and spark plug electrodes after fueling with unleaded fuel for an extended period of time.

3.0 TEST VEHICLES

Ten vehicles were tested in this study. Each vehicle was a 1981 or newer gasoline-fueled passenger vehicle equipped with a three-way catalyst (with or without an additional oxidation catalyst) and close-loop configuration. All vehicles had accumulated at least 4000 miles prior to the tests. The test vehicles used were screened for absence of indications of previous leaded fuel use. Screening consisted of testing the vehicle's fuel for lead content prior to entry into the program ($<$ 0.05 g/gal Pb), inspection for enlarged fuel inlet restrictors, and a Plumbtesmo test of tailpipe deposits. Any indication of previous use of leaded fuel was cause for rejection. An exception was granted to the owner of vehicle

#520 because the vehicle had been involved in a previous fuel switching program. However, at the end of the previous program, the vehicle's exhaust pipe, catalytic converter, muffer and tailpipe had been replaced.

The vehicle types consisted of seven General Motors vehicles, one Ford vehicle, one Chrysler vehicle, and one Toyota vehicle. A list of the vehicles, their engine size, induction type, VIN and engine family can be found in Table 1.

4.0 TEST DESCRIPTION

The vehicles were initially fueled with the low lead gasoline. The vehicles accumulated mileage on public roads, in normal driving, by the vehicle owners. Fuel was provided to the vehicle owners without charge as an incentive. After each refueling, the vehicles' tailpipes were tested using Plumbtesmo brand lead detection paper.

Each vehicle was continuously refueled with the low lead fuel until tailpipe lead deposits were detected in the tailpipe at four consecutive fill-ups or until three months after the start of 0.1 gram/gal fuel use, whichever occurred first. If lead deposits were detected with lead detection paper after four consecutive fill-ups, the vehicle was switched to unleaded gasoline for the remainder of the three-month testing period.

After all testing was completed, the misfueled catalyst, oxygen sensor, tailpipe, and spark plugs were replaced and the lead poisoned parts shipped to EPA for possible further analysis.

5.0 TEST PROCEDURE

In this study, the Plumbtesmo tests were conducted outside, on warm vehicles (tailpipe was not so hot that it could not be touched), and during the period from May to October.

The test procedure was as follows:

The inside of the tailpipe was degreased by spraying acetone onto it. The acetone was allowed to evaporate and the excess solvent or soot was not wiped away.

The Plumbtesmo paper was then cut in half and moistened with three drops of distilled water. The moistened paper was pressed against the inside side surface of the tailpipe and held there for one minute by the individual conducting the test. After one minute, the test paper was removed and judged as to whether a pink color was present. This indicated a positive presence of lead.

If the test was positive, a confirmatory test was performed on the same spot in the tailpipe. If the test was negative, i.e.,a color change was not observed, the tailpipe was wiped out and degeased with acetone. The test was then performed again at the same location

If the second test at the same spot was negative, the tailpipe was again degreased and the test was performed on the bottom of the inside tailpipe surface. If after the three tests, no positive result could be determined, an overall "negative" result was recorded. If any test in any spot produced a reaction, a "positive" result was recorded.

6.0 RESULTS

The lead detection paper results are shown in Tables 2-4. For all vehicles a Plumbtesmo failure occurred at or prior to the sixth tank of low lead fuel. For all but one vehicle, a 1984 Chevrolet Cavalier, the first failure occurred at or prior to the fourth tank. Three GM vehicles experienced a Plumbtesmo failure after only one tank of the leaded fuel.

The number of unleaded tanks that a particular vehicle received varied from two to twenty-five. For some vehicles, the presence of lead as detected by a positive Plumbtesmo reaction never disappeared; while on other vehicles, the positive Plumbtesmo vanished after just one tank of unleaded fuel. Consequently, no definite conclusions regarding the disappearance of lead deposits on tailpipes from unleaded gas usage can be made. However, the disappearance of a positive Plumbtesmo reading occurred on most vehicles after four tanks of unleaded fuel use.

During the course of the test program several problems occurred. For instance, difficulties in blending the second batch of low lead fuel caused unscheduled unleaded fuel usage in vehicles 512, 513, 517, and 520. Similarly, vehicle 516 was filled twice away from the laboratory with unleaded fuel. Vehicles 511, 512, 515 and 517 were "topped off" before a trip, but did not receive Plumbtesmo tests at those points.

Vehicle 517 had cold start driveability problems near the end of the program. Replacement of the oxygen sensor and spark plugs at the end of the program cured the complaint. Also, the front converter on vehicle 518 melted down and partially plugged the rear converter. The owner had noticed a deterioration in driveability which was eliminated following replacement of the converter, plugs and sensor at the end of the program.

One concern when using Plumbtesmo paper was that large amounts of deposited lead would be removed from the tailpipe

during repeated Plumbtesmo tests. This question was resolved by removing the tailpipe from the vehicle and testing an internal portion of it at the end of the testing program. The results of testing an internal portion of the tailpipe were no different than those performed at the normal outlet.

Plumbtesmo tests were performed on oxygen sensors and spark plugs from the vehicles after they completed the final fueling with unleaded gasoline. The number of unleaded tanks that a particular vehicle received varied from two to twenty-five. The Plumbtesmo paper, in all cases, gave a bold pink reaction indicating the presence of lead on the oxygen sensor. Plumbtesmo tests performed at the vehicles' spark plug electrodes, after the final fueling with unleaded gasoline, showed the presence of lead on most of the spark plugs from all of the vehicles. One spark plug from vehicle 511 tested negative for lead and the other plugs from that vehicle produced only faint pink reactions. The negative Plumbtesmo reaction correlates well with the relatively high amount of unleaded fuel (180 gallons) which vehicle 511 consumed prior to the final Plumbtesmo test. This result indicates that the presence of lead due to misfueling may disappear from spark plugs after the vehicle has operated on unleaded fuel for more than 6000 miles. In a similar misfueling study done by General Motors (ref 1.), it was found that the degree of Plumbtesmo reaction decreased similarly.

References

1. McIntyre, Barbara R. and Faix, Louis J., "Lead Detection in Catalytic Emission Systems and Effects on Emissions. SAE Paper 860488, February 1986.

2. Michael, R. Bruce, "Misfueling Emissions of Three-way Catalyst Vehicles." SAE Paper 841354, October 1984.

3. "Misfueling with Reduced Lead Content," Prepared by Automotive Testing Laboratories for EPA under Contract 68-03-3230, September, 1986.

Table 1

Test Vehicle Information Table

VEH	#VEHICLE DESCRIPTION	ENGINE FAMILY	VIN NUMBER
511	1983 Olds Cutlass	D4G3.8V2NEA3	1G3AR47A7DM550973A
512	1983 Olds Cutlass	D4G3.8V2NEA3	1G3AR47A4DM5543514
513	1984 Chev. Cavalier	E1G2.0V5XAJ5	1G1AD69PXEJ1092641
514	1983 Chev. Citation	D1G2.8V2NNA9	1G1AXCBX7DT101244
515	1985 Buick Skyhawk	F1G2.0V5XAG1	1G4JT27P8FK479237
516	1983 Ford Thunderbird	DFM5.0V5HLFB	1FABP46F3DHI42704
517	1983 Buick Regal	D4G3.8V2NEA3	1G4AM69A1DH813308
518	1983 Dodge Diplomat	DCR3.7V1HAS3	2B3BG46H5DR104747
519	1982 Buick Skylark	C2G2.5V5TPG5	1G4AB37R6CT106181
520	1981 Toyota Celica	BTY2.4V2EF6	JT2RA44L3B0026720

Table 2

VEHICLE PLUMBTESMO TEST RESULTS

VEHICLE	511	512	513	514	515	516	517	518	519	520
Incoming	P	P	P	P	P	P	P	P	P	P
TANK 1	F	F	P**	P	F	P	P	P	P	P
TANK 2	F	P	P	P	F	P	P	P	P	P
TANK 3	P	P	P	P	F	P	P	F	P	P
TANK 4	F	P	P	F	F	F	F	F	F	F
TANK 5	F	P	P	F	F	F	1	F	F	F
TANK 6	F	F	F**	F	F*	F	P**	F*	F	F**
TANK 7	F*	1	F**	F*	F	P	F	F	F	F*
TANK 8	F	P**	F	F	P	2	F	F	F*	F
TANK 9	F	P**	F	-	F	2	F	F	P	P
TANK 10	P	F	F*	-	P	P	P	F	P	F
TANK 11	F	P	P	-	P	P	P	F	P	P
TANK 12	P	P	P	-	P	P	P	F	-	P
TANK 13	P	P	-	-	P	-	P	F	-	P
TANK 14	P	P	-	-	1	-	-	F	-	P
TANK 15	F	P	-	-	-	-	-	F	-	P
TANK 16	F	P	-	-	-	-	-	F	-	-
TANK 17	F	P	-	-	-	-	-	P	-	-
TANK 18	P	-	-	-	-	-	-	P	-	-
TANK 19	P	-	-	-	-	-	-	P	-	-
TANK 20	F	-	-	-	-	-	-	P	-	-
TANK 21	P	-	-	-	-	-	-	F	-	-
TANK 22	P	-	-	-	-	-	-	-	-	-
TANK 23	P	-	-	-	-	-	-	-	-	-
TANK 24	P	-	-	-	-	-	-	-	-	-
TANK 25	P	-	-	-	-	-	-	-	-	-
TANK 26	P	-	-	-	-	-	-	-	-	-
TANK 27	P	-	-	-	-	-	-	-	-	-
TANK 28	P	-	-	-	-	-	-	-	-	-
TANK 29	P	-	-	-	-	-	-	-	-	-
TANK 30	P	-	-	-	-	-	-	-	-	-
TANK 31	P	-	-	-	-	-	-	-	-	-
TANK 32	P	-	-	-	-	-	-	-	-	-

P = Pass or negative Plumbtesmo results.
F = Fail or positive Plumbtesmo results.
1 = Vehicle received only a half a tank of of leaded fuel.
2 = Vehicle was filled with unleaded on road. No test was performed.
* = Vehicle was permanently switched to unleaded fuel.
** = Vehicle was temporarily switched to unleaded fuel due to fuel blending problems.

Table 3

Vehicle	MYR	Vehicle	Engine Size	Catalyst Type	Leaded Tanks	Leaded Gals	Leaded Miles	Total grams of Lead	Tailpipe Plumbtesmo: 1st Pb Failure (tanks)	Tailpipe Plumbtesmo: 1st Pb Failure (gals)	Tailpipe Plumbtesmo: Plumbtesmo Oxygen Sensor	Tailpipe Plumbtesmo: Presence of Lead Spark Plugs
511	83	Olds Cutlass	3.8L	OX/3CL	7	99.7	1748	10.0	1	14.2	Yes	yes***
512	83	Olds Cutlass	3.8L	OX/3CL	15	215.4	4395	21.5	1	14.4	Yes	yes
513	84	Chevy Cavalier	2.0L	3CL	7	72.4	1781	7.2	6	62.1	Yes	yes
514	83	Chevy Citation	2.8L	OX/3CL	7	91.2	1613	9.1	4	52.1	Yes	yes
515	85	Buick Skyhawk	2.0L	3CL	6	69.9	1979	7.0	1	11.7	Yes	yes
516	83	Ford T-Bird	5.0L	OX/3CL	11	155.4	2236	15.5	4	56.5	Yes	yes
517	83	Buick Regal	3.8L	OX/3CL	12	155.7	3087	15.6	4	51.9	Yes	yes
518	83	Dodge Diplomat	3.7L	OX/3CL	6	80.0	1511	8.0	3	40.0	Yes	yes
519	82	Buick Skylark	2.5L	3CL	8	90.4	1779	9.0	4	45.2	Yes	yes
520	81	Toyota Celica	2.4L	3CL	6	79.4	1715	7.9	4	52.9	Yes	yes

Table 4

Vehicle	MYR	Vehicle	Engine Size	Catalyst Type	Unleaded Tanks	Unleaded Gals	Unleaded Miles	Tailpipe Plumbtesmo after unleaded fuel use: Last Pb Failure (tanks)	Tailpipe Plumbtesmo after unleaded fuel use: Last Pb Failure (gals)	Comments
511	83	Olds Cutlass	3.8L	OX/3CL	25	347.0	6441	13	180.4	
512	83	Olds Cutlass	3.8L	OX/3CL	2	29.6	607	-	-	*
513	84	Chevy Cavalier	2.0L	3CL	6	61.9	1473	1	10.3	*
514	83	Chevy Citation	2.8L	OX/3CL	2	24.3	440	-	-	*
515	85	Buick Skyhawk	2.0L	3CL	8	93.4	2653	4	46.7	
516	83	Ford T-Bird	5.0L	OX/3CL	2	24.9	568	-	-	**
517	83	Buick Regal	3.8L	OX/3CL	1	14.5	300	1	14.5	*
518	83	Dodge Diplomat	3.7L	OX/3CL	16	207.7	3502	11	142.8	
519	82	Buick Skylark	2.5L	3CL	4	42.5	892	1	10.6	
520	81	Toyota Celica	2.4L	3CL	10	142.3	3109	4	56.9	*

Comments:

* During the misfueling portion of this test, the car was temporarily put on unleaded fuel.

** The vehicle's fuel was re-filled on the road. See text.

*** Lead was not detected on every spark plug of this vehicle.